studied. For this purpose Bergeron has made use of Köppen's mean wind charts as the best available criterion.

(2) Mean positions and long-period departures from the mean positions of the climatic fronts must be noted. Explanation of departures from the normal position of such zones, i. e., displacement of the belts of maximum storminess, or cyclone paths, must be looked for in the dynamic or thermodynamic factors (see list above) controlling the particular center of action whose displacement or changed activity is responsible for the displacement of the climatic front.

(3) Finally there is required the systematic observation of the frequency of occurrence of warm and cold air masses at each station, and the relation of all the meteorological elements, especially the hydrometeors, to the prevailing air mass type. The frequency of change from one air mass to another should give in temperature regions a measure of the proximity and activity of the climatic front, and an indication of the contribution of active front passages to the climate of the region, particularly the precipitation and cloudiness.

WINDSTORM IN THE LOS ANGELES AREA NOVEMBER 22, 1930, AND SOME EFFECTS OF WIND FLOW IN A MOUNTAINOUS REGION

By GEORGE M. FRENCH

[Weather Bureau Office, Los Angeles, Calif., July, 1931]

Near midnight of November 21, 1930, one of the strongest winds of record began in the Los Angeles area and continued until about midnight of November 22. Winds aloft and on the surface were from the northeast except where they were deflected by topography.

Following the passage of a low over the southern portion of the western plateau region on November 18, 1930, a high pressure area moved in rapidly from the Pacific Ocean over the Northwestern States and when reaching the plateau region became almost stationary as is common in that region especially during the early winter months. This high built up rapidly being reinforced by additional ocean highs and as shown on the 8 p. m. synoptic chart of November 21, it was central over Idaho, eastern Oregon, and western Montana with a pressure of 30.82 inches. The pressure gradient had by this time become quite steep between the plateau and the coastal valleys of California and the high was still increasing in energy.

The influence of this high was little felt in southern California as far as either surface winds or those aloft were concerned during the day of November 21, 1930, but a little before midnight on that date surface winds increased rapidly and became strong with frequent gusts of gale force. The next morning, November 22, the synoptic chart showed the high central in Idaho and northwestern Wyoming with the highest reading at Yellowstone, 31.02 inches, reduced to sea level.

Three hourly airway weather maps of California for 11 a. m., 2 p. m., and 5 p. m., eastern standard time, are shown by figures 1, 2, and 3. As the map is on quite a large scale, isobars are drawn for every 0.05 inch difference in pressure. These maps show the steep gradient that prevailed over the mountains on November 22 and the relatively low pressure on the lee side of the mountains, which is largely due to the strength of the wind.

From experience the writer believes that under ordinary pressure gradients, mountains as high and as precipituous as the San Gabriel Range act as a barrier to north winds in the Los Angeles area. In such cases high winds proceed southward over the mountains and remain aloft, gradually lowering and reaching the surface in the vicinity of the ocean shore line or farther out, leaving the Los Angeles area in light to moderate variable winds. However, in such cases the wind pours through the low points in the mountains, as for example Cajon Pass, and frequently proceeds southward at gale force through Santa Ana Canyon in the Santa Ana Mountains and thence southward to the ocean, thus producing the "Santa Ana" as the wind of this type has been popularly called in southern California. I once had the opportunity to observe such a wind from the top of Santiago Peak. The course of this rapidly moving air was easily traceable by the dust and could be followed in that manner from Cajon Pass to the ocean.

It appears, by study of winds in the Los Angeles area, that if the gradient is quite steep between the plateau high and the coastal area that high northerly winds in passing over the mountains will not only reach the surface in lee of low passes but will also follow the contour of the lee side of the high mountains and in that case high northerly winds are general over the whole Los Angeles area as was the case on November 22, 1930.

There were three points in and near Los Angeles where wind instruments were located at the time of the storm. They were located as follows: Weather Bureau office, Los Angeles; airport at Alhambra, and the Weather Bureau airport station, Glendale. The writer was located at the latter point. The strength and duration of the wind was quite similar at Glendale and Alhambra but the velocities were lighter and the duration much shorter at the Weather Bureau office, Los Angeles, a condition that frequently prevails in times of high northerly winds. The Weather Bureau office in Los Angeles is remarkably free from high northerly winds although the exposure is excellent.

The high winds at Glendale had two maximum periods on the surface, 2 to 4 a. m. and 12:30 to 4 p. m., with gusts in excess of 60 miles per hour during the latter period. As far as could be ascertained, the highest winds aloft occurred near the middle of the forenoon.

The first upper air observation on the day of the wind storm was attempted at 3 a. m. but with several attempts only 3 minutes were secured due to dust. Shortly before 9 a. m. upper air observations were again attempted and after several trials one was secured of nine minutes with an indicated altitude of 5,600 feet. In each of the attempts the balloon moved southwestward rapidly in the beginning then was retarded at approximately the same length of time after release and then would again move out much more rapidly than before. The first attempts were lost soon after reaching the second high velocity either due to dust or to the vibration of the theodolite.

In Figure 4 a cross section of the mountains and valley north and south and passing through the airport station at Glendale is represented. Wind flow over the mountains and valleys is represented by arrows flying with the wind giving my idea of both the nature of the flow over the mountains and the relative speed. The relative speed is indicated by the length of the arrows, longer arrows representing greater speed. This is based on available data and the general knowledge that I have gained mostly in the aerological work of wind flow over a mountain range.

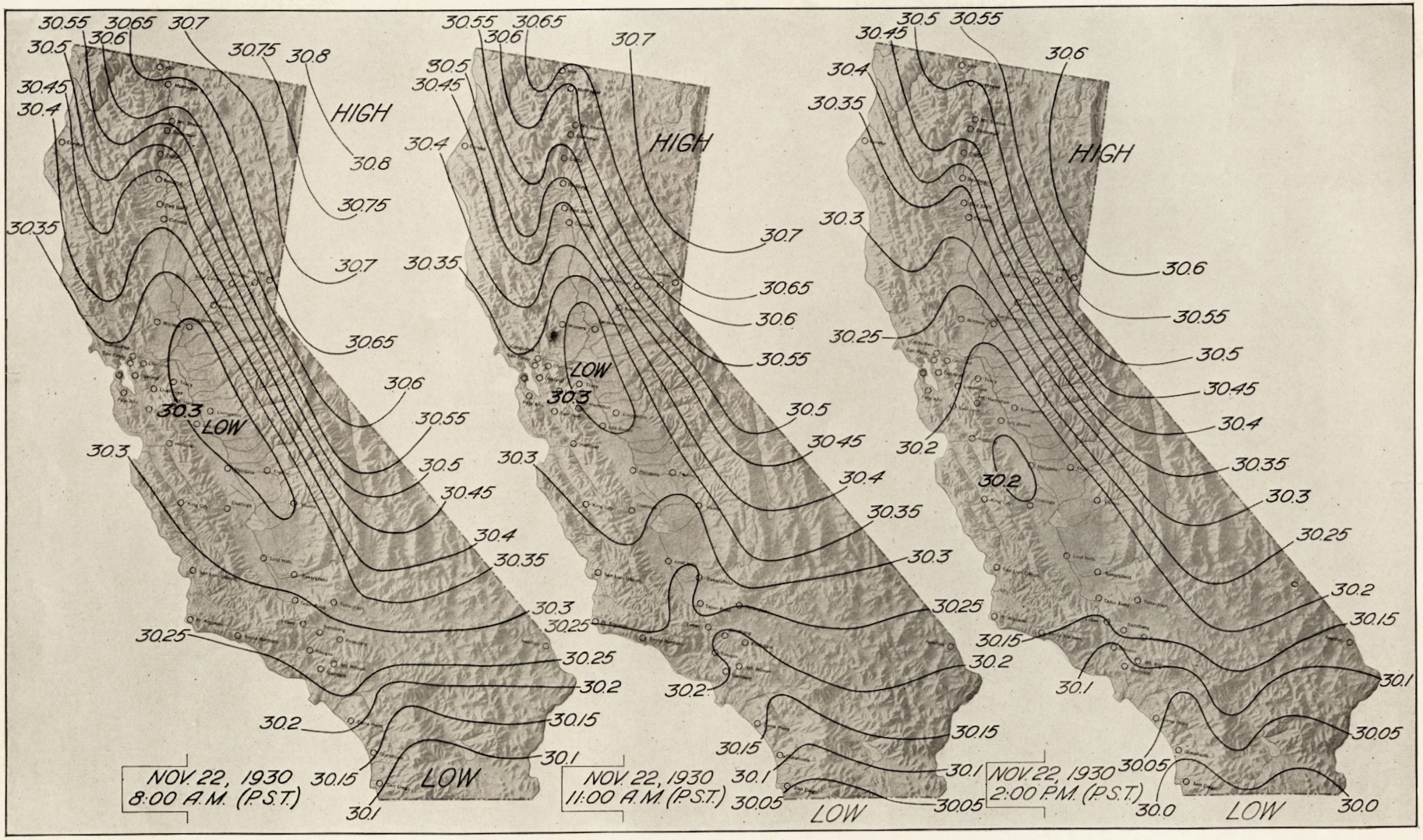

FIGURE 1.—Weather chart 8 a. m. (P. S. T.) November 22, 1930

FIGURE 2.—Weather chart 11 a. m. (P. S. T.) November 22, 1930

FIGURE 3.—Weather chart 2 p. m. (P. S. T.) November 22, 1930

(To face p. 224)

During the wind storm occasionally the wind would suddenly shift at the Glendale station to south or southwest and blow nearly as hard from that direction as it had from the northeast, reaching extremes of 50 miles per hour or more. This is believed to be the result of vertical eddies as represented in Figure 5. This reversing of the wind also occurred at Alhambra but was little noticed at the Weather Bureau office in Los Angeles, which point is farther removed from the mountains.

Flying was discouraged as far as possible in all our contacts with pilots both as to conditions aloft and especially on account of bad wind conditions for landing or taking-off.

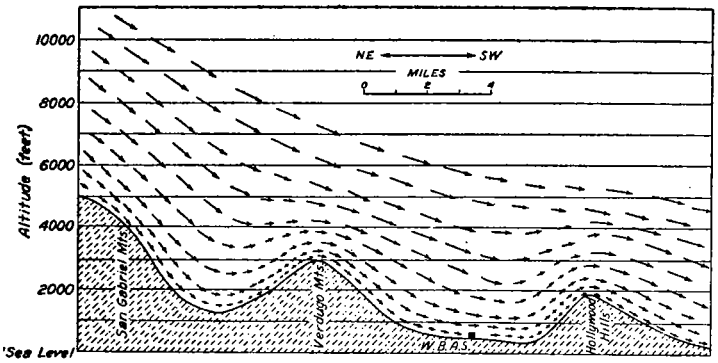

FIGURE 4.—Cross section showing the contour of the land from a point near the top of Sister Elsie Peak, in the San Gabriel Mountains, southwestward through the Verdugo Mountains and Weather Bureau Airport station in the San Fernando Valley, thence through the Hollywood hills near Cahuenga Peak. Arrows indicate the wind flow believed to have prevailed during the greater portion of the wind storm of November 22, 1930

Nearly all the scheduled flights were canceled, but four known flights were made. One scheduled flight was accomplished from Salt Lake City to Los Angeles which was made in 4 hours and 15 minutes as compared with 7 hours and 15 minutes scheduled time. Another flight was attempted from Los Angeles to San Francisco. The pilot came into our office after the attempt and said that he went up to 8,000 feet to avoid extreme bumpiness and was making an air speed of 110 miles per hour.

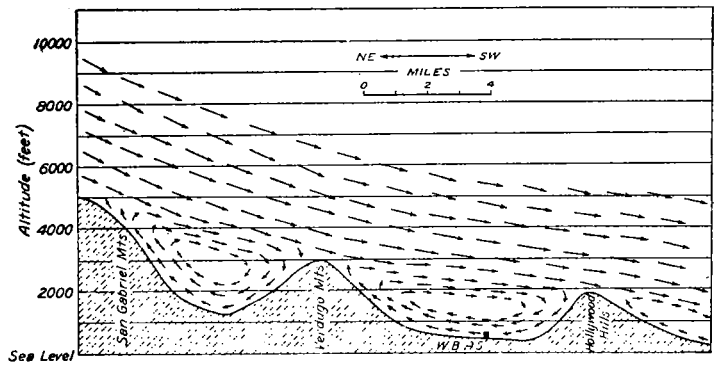

FIGURE 5.—Cross section showing the contour of the land from a point near the top of Sister Elsie Peak, in the San Gabriel Mountains, southwestward through the Verdugo Mountains and Weather Bureau Airport station in the San Fernando Valley, thence through the Hollywood hills near Cahuenga Peak. Arrows indicate wind flow believed to have taken place over this contour on November 22, 1930, showing vertical currents in the lee of the higher hills

He noticed that he was making very little if any headway and he sighted on a water tank below him and found that he was not only making no headway forward but was being carried slowly to one side. He immediately landed at Glendale and found landing conditions very dangerous.

Our upper air observation at 9 a. m. was taken shortly after the attempted flight described above. The following velocities were indicated from the data obtained from the pilot balloon flight (altitudes in feet and wind speeds in miles per hour):

Surface, NNE. 19.	3,200 feet, NNE. 21.
700 feet, NE. 34.	3,800 feet, NNE. 36.
1,400 feet, NE. 51.	4,400 feet, NE. 102.
2,050 feet, NE. 57.	5,000 feet, NE. 168.
2,650 feet, NE. 47.	5,600 feet, NE. 186.

This observation is also plotted on Figure 6 for direction and velocity with elevation in meters and velocity in meters per second.

Again referring to Figure 4 it was found that by comparing distance out of the balloon with the distance of the Hollywood hills from the airport station that the balloon would have reached the area of rising currents and diminished velocity on the windward side at about the time the run showed a sharp decline in velocity. I believe it is therefore safe to assume that the apparent decrease in velocity was partly due to retarded wind movement and partly to rising currents which would indicate a lighter velocity according to our method of determining winds aloft.

The diminished wind velocity on the upper air observation was immediately followed by a rapid increase in

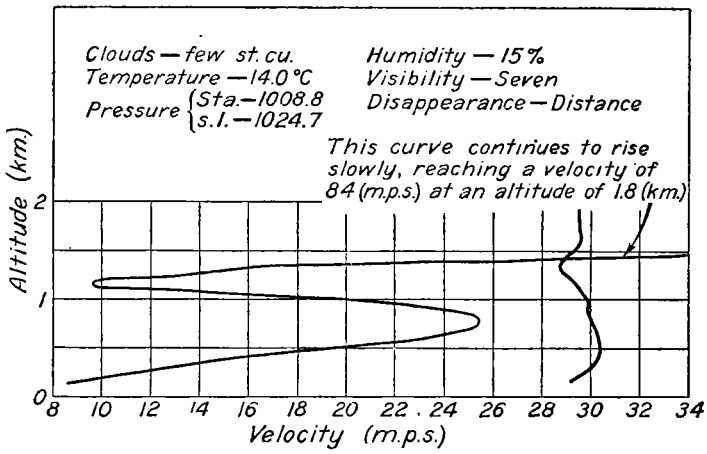

FIGURE 6.—Pilot balloon flight at Glendale, Calif., 9:23 a. m., November 22, 1930

velocity which also conforms with Figure 4, as it is believed that the balloon was then entering the increased wind velocity indicated on the lee side of the Hollywood hills and in addition there was a downward movement to the air giving a lower elevation angle than should have been recorded which in turn indicates a velocity greater than what actually existed. Winds undoubtedly occurred, however, of 110 miles per hour or more as evidenced by one aviator's experience.

In most cases where strong winds bring continental air into this region, with the exception of cases where precipitation has occurred just previously, very dry and clear weather prevails. However, in this case there was sufficient moisture in the continental air that the forced convection over the mountains formed storm clouds all along the north slope of the San Gabriel and San Bernardino Mountains and blizzards prevailed in that region. The clouds dissipated rapidly on the lee side and the air was relatively dry at Glendale. This storm condition subsided as soon as winds aloft had materially decreased.

Considerable damage was done during the storm. A trimotored plane was torn from its anchorage during the early morning hours at the Grand Central Airport, Glendale, and was rolled by the wind about half a mile across the field and left upside down at the opposite end. The plane was so badly damaged that it could not be

repaired. Other damage, such as small buildings demolished, occurred on the field. In other parts of the city telegraph poles, trees, small buildings, and roofs were either damaged or blown down, and a few people lost their lives by being hit by falling objects.

It is my belief in studying this storm and the available data in connection with other local and general winds in this area that moderately strong winds will generally flow over a mountain having gentle sloping sides, especially if the mountains is not very high, in much the same manner as the flow of air that moves over the cambered surface of an airplane wing, the result being reduced pressure [1] and increased velocity of wind in lee of the highest point. In such cases, I believe that a high precipitous mountain will act as a barrier and the wind will not descend directly down the leeward side but reduced pressure will occur on the lee side as in the other case. When very high winds prevail, I believe that they will often descend the leeward side even of high precipitous mountains, but the flow will be variable and great turbulence prevail.

[1] Detailed airway weather maps for California at times showed peculiar pressure distributions which seemed to be out of harmony with the rest of the map. Mr. D. M. Little first drew these pecularities to my attention and pointed out that it was due to the compressing of air on the windward slopes of mountains and the expansion on the leeward side as a result of the general wind flow over the region.

THE GOTHENBURG, NEBR., TORNADOES JUNE 24, 1930

By ALFRED RUSSELL OLIVER

Tuesday evening, June 24, 1930, a series of tornadoes began in Lincoln County, Nebr., swept southeastward across Dawson County, and ended in Phelps County, leaving behind them a path of destruction 70 miles long and varying in widths from a quarter of a mile to 2 miles. (Fig. 1.) The storm was first observed about 3 p. m., struck its first blow about 5:30 p. m., and was over by 8 p. m.

The weather map for Tuesday morning, Figure 2, shows that almost the entire United States west of the Mississippi was covered by an area of low pressure. Over most of this area the variations in pressure did not exceed two-tenths of an inch, the extremes being 29.7 and 29.9 inches. Thus the barometric gradient over the entire western part of the country was very slight. These conditions are typical of those which produce the common thunderstorm of this country. A HIGH, with a pressure of 30.1 inches, was centered over western Oregon; another, with a pressure of 30 inches, existed over southern Louisiana. (See figs. 2 and 3.)

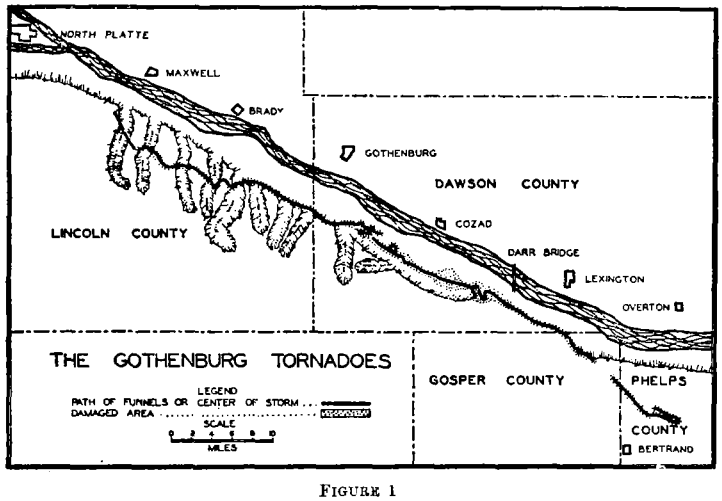

FIGURE 1

The tornadoes occurred between 5 p. m. and 8 p. m. In some cases coincident with them, but generally somewhat later, violent thunderstorms, accompanied by strong winds, occurred at several points in Nebraska, north, south, and east of the tornado belt, but there was no general storm over the State. That tornado conditions seem to have started developing west of North Platte is indicated by reports of violent agitation of the clouds 15 miles west of there. These clouds moved eastward along the Platte Valley. At North Platte two clouds appeared to unite, one coming from the west, the other seeming to materialize out of the air overhead. Both were rolling and tumbling and boiled upward as they came together. The new cloud continued southeastward about 14 miles toward Boxelder Canyon, becoming darker, more agitated, and continuously more threatening. Behind this cloud was the thunderstorm which brought the rain and hail, a not unusual condition under such circumstances.

The location of North Platte in the formative area of the tornado makes the weather observations there especially significant. In this connection it should be

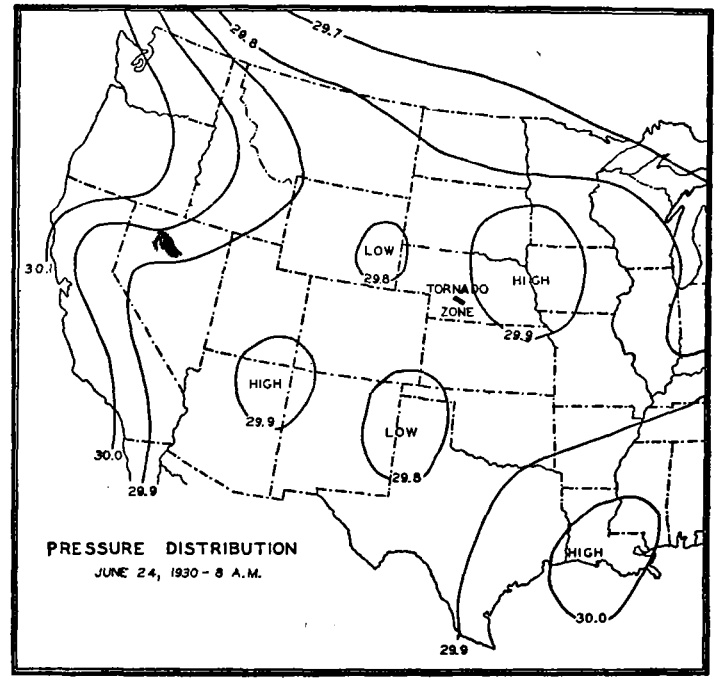

FIGURE 2

remembered that the storm was forming from 3 p. m. to 5:30 p. m. and was over by 8 p. m. A heavy thunderstorm prevailed at North Platte [1] from 3:55 p. m. to 5:45 p. m., with a rain lasting until 4:29 p. m., then a heavy hail for 15 minutes, and then rain again until 4:57 p. m. The rainfall for the afternoon was 0.32 inches. Hailstones 2 inches in diameter were picked up, consisting of from 75 to 100 ice pellets frozen together. A continuous roaring, as of trains passing through a tunnel, was heard before and after the rain and hail. The barometer fell steadily from 26.98 inches at noon to 26.85 inches at 7 p. m. The temperature dropped from

[1] Detailed information concerning conditions at North Platte was supplied by Mr. A. W. Schilling, junior meteorologist there.